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10/549931

JC17 Rec'd PCT/PTO 20 SEP 2005

Method for the production of a dental moulded part

5 The present invention relates to a method for the production of a dental moulded part in accordance with the preamble of claim 1 or of claim 20. In particular the present invention relates to a method for the production of moulded parts of noble metal alloys or non-iron metal alloys which are difficult to work.

10 In dental technology tooth prosthetic provisions are produced of the most varied materials, depending upon indication, aesthetic requirements, health consciousness and financial situation of the patient. As a result of new production technologies such as laser welding, galvano-
15 technics and not lastly through the advance of dental CAD/CAM-systems, today there can be put to use, alongside the classical noble metal casting alloys, also new biocompatible materials in the form of semi-finished materials such as titanium, glass ceramics, high
20 performance ceramics or plastics.

The proportion of classical noble metal casting alloys, in the production of fixed or combined (so-called attachments) tooth prostheses, is as before very high. This is the case
25 because noble metal alloys have proved over decades to be very dependable in the mouth of the patient, tolerant in the case of constructional configuration and design faults and, not least, manifest a high biocompatibility. A further advantage of noble metal alloys further consists in that for
30 these moulded parts a proven range of tested and easily workable veneer ceramics are available.

However, in the case of production of noble metal tooth prostheses with dental CAD/CAM systems against these advantages there stand the high stocking costs for the necessary semi-finished items and the considerable costs for the separation of the machining waste noble metal, whereby it is to be taken into consideration that at the present time the level of machining waste lies above 90%. Consequently, to date most attempts at a production of noble metal tooth prostheses by means of CAD/CAM systems in dental or practice laboratories have failed for cost reasons.

In the production of tooth prosthetic parts of NIM (non-iron metal) alloy semi-finished products with the aid of CAD/CAM systems, the problem of the difficult machinability of the Co-Cr-Mo ceramic alloys stands in the foreground. The savings though the employment of economical NIM alloys are cancelled out by the high wear of expensive milling machines and the long working times, which lead to high machine hour costs.

One proposal for avoiding the above-mentioned problems in the production of tooth prostheses of noble metal or NIM alloys is so-called laser sintering. Such equipment requires, however, a huge investment of the level of several hundred thousand Euros, which cannot as a rule be committed by a dental or practice laboratory. Further, with the layer-wise build up of the parts physical limits apply to the precision, so that in turn long, complicated, mechanical and manual finishing is necessary. The production of the fine metal powder necessary for the sintering process is, beyond

this, technologically very complicated and particularly in the case of noble metals not economic. Further, the dental technician must pass on the basis of his prosthetic work, i.e. pass it on to external workshops, so that waiting times
5 arise and the dental technician again loses a substantial component of his financial chain of production.

A method for the production of dental moulded parts of noble metal alloys, which at least partly uses the advantages of a
10 CAD/CAM system, is known from US 5,224,049. Here, after a model of the moulded part to be formed has been produced, there is selected from a series of predetermined mould forms (so-called coquilles), that coquille the structure of which comes closest to the moulded part to be produced. If there
15 are still deviations from the moulded part to be produced, the coquille is worked for so long until the hollow space corresponds to the moulded part to be produced. Then, this is filled with material, for example a noble metal alloy, which can be hardened.

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By means of the method known from US 5,224,049 the outlay for the production of a dental moulded part is thus reduced; it has however been found that this method has certain limits with regard to its precision. In particular more
25 complicated surface structures of the dental moulded part can be realized with the necessary precision only with difficulty.

The present invention thus is based on the object of
30 indicating a possibility of producing also dental moulded parts with complicated structures in as rationalized a

manner as possible. In particular there should be the possibility of being able to use the advantages CAD/CAM technology as comprehensively as possible.

- 5 The object is achieved by means of a method for the production of a dental moulded part in accordance with claim 1 and by means of a method in accordance with claim 20. The subclaims relate to advantageous further developments of the method in accordance with the invention.

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In accordance with the present invention, the method for the production of a dental advantage consists in substance of the following four steps:

- a) production of a model of the moulded part to be formed,
15 b) production of a coquille, having a hollow space the form of which corresponds in substance to the form of the model,
c) production of a casting by filling of the coquille hollow space with a material which can be withstood and
d) allowing the casting to harden.

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- In accordance with a first insight according to the invention, the model produced in step a) is provided with an offset, which is taken into account in the production of the coquille, whereby after the hardening of the casting this
25 is worked by material removal in order finally to produce the dental moulded part. The thickness of the offset may thereby depend both on the form of the moulded part to be produced and also on the hardenable material, and the offset may cover the model in part or also completely.

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The present invention links or supplements the advantages of classical CAD/CAM technology with classical casting technology in a modified form and in this way makes possible a highly precise, partly automated and economical production of the tooth prosthetic workpieces of noble metal alloys or Co-Cr-Mo alloys in a dental or practice laboratory. In comparison to the method known from US 5,224,049, the production of the coquille is simplified, since through the employment of the offset more complex structures in the surface of the moulded part to be produced can be compensated, so that the coquille can be worked relatively quickly and simply. In comparison to the known method, although there is then still subsequently needed a working of the hardened casting, the advantage is however provided that with this in the end the desired moulded part can be produced with a very high precision. Beyond this, in accordance with the method in accordance with the invention, also more complicated surface structures can be created for the moulded part, which otherwise could be realized only with difficulty or not at all.

In order to be able to fully use the advantages of CAD/CAM systems, in accordance with a particularly preferred variant of the method according to the invention it is provided that the coquille is produced by means of fully automatic material removing working, in particular by means of milling, turning, boring, and/or grinding of at least one coquille blank. Here, a material removal program taking into account the desired contours of the coquille gives control commands for a material removal machine, wherein the program is produced in particular also the basis of a three-

dimensional CAD reconstruction of the model provided with the offset. Further it can be provided that upon production of the coquille at the same time at least one inlet channel is worked into the blank, via which then subsequently the
5 hardenable material is filled.

Corresponding to a second insight of the present invention it is provided that after the hardening of the casting this is, for finishing working, still embedded - i.e. together
10 with the coquille, placed in a mould receiver and worked there. Preferably there is involved the same material removal machine which was already employed previously for the production of the coquille. Since in this case an exact repositioning of the still embedded casting in the tool
15 machine is made possible, a high precision of the subsequent working of the moulded part is ensured.

A particular advantage is further provided with this second inventive insight in that the coquille material can serve at
20 the same time as millable or grindable support or retaining material, so that also the working of very thin and per se fragile castings is possible. After a partial milling away of the coquille material it can then be provided to again embed behind the casting with another support material and
25 then work the remainder of the casting occlusally.

Overall, there is thus provided by means of the present invention the possibility of producing dental moulded parts of noble metal alloys or NIM alloys in a very effective
30 manner, whereby at the same time a precision as great as possible is ensured in the production of the moulded part.

Below, the invention will be described in more detail with reference to the accompanying drawings. Thereby there is shown:

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Figs. 1 to 10 the various steps of a preferred exemplary embodiment of the method in accordance with the invention and

Fig. 11 a tabular overview of the method steps of the
10 classical method for the production of a dental casting and of the method in accordance with the invention.

The method in accordance with the invention for the production of dental moulded parts represents, in comparison
15 to the classical method for the production of gold castings, a clear step forward, since many of the working steps normally to be carried out can now be carried out automatically or by machine. For clarification of the advantages in accordance with the invention, the classical
20 method for the production of an individual gold cap will be briefly summarized below.

Thereby, after conclusion of the preparatory operations, initially a foil cap is deep drawn, which is then adapted to
25 the previously worked tooth stump. After insulation of the tooth stump the foil cap is fixed and then a wax model of the crown to be made is produced. This wax model is now lacquered and then the casting prepared, for which purpose first the muffle is prepared, a bedding mass slurry produced
30 and the model of the wax crown finely embedded. After completion of the embedding, the muffle is waxed out and

pre-warmed and finally poured with the liquid noble metal alloy. After hardening of the casting, this is bedded out and the casting blank finish cleaned and the inlet channel separated.

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Then, the cast piece produced in this manner can be worked with a handpiece until it assumes the form of the desired crown cap. This cap is then, for the purpose of surface treating, blasted and cleaned. After a cleaning of the tooth
10 stump, the cap can then be put in place in the final operation.

The method known to date is summarized in tabular form in Fig. 11. As can be taken from the above summary, a great
15 part of the tasks to be undertaken in the classical method are to be carried out manually, wherein some of the working steps take up a long period of time. In particular the modelling of the crown in wax and the working of the casting with the handpiece take up relatively much time. In contrast
20 to this, with the aid of the present invention, the production method can be significantly speeded up and automated, as explained below.

The beginning of the method in accordance with the invention
25 thereby corresponds to the classical production method, i.e. within the scope of preparatory operations the tooth is first worked and then there is produced with appropriate monitoring of the working documentation, and the model, margins etc., the tooth stump illustrated in Fig. 1,
30 provided in general with the reference sign 1, or a positive model of the same. The stump 1, produced by means of

classical impressing and the like is then three-dimensionally optically measured and for this purpose an appropriate measurement device put to use, as is generally known from CAD/CAM systems.

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As soon as the data regarding the three dimensional structure of the tooth stump is completely available, there can then be effected, PC controlled, an automatic surface reconstruction, which finally leads to the construction of
10 the crown cap. With the aid of classical CAD-3D technologies, here the crown cap is largely automatically generated, on the so-called NURBS (non-uniform rational B splines) surface; that is on the stump geometry described with the aid of a mathematically complex method, and - so
15 far as it is necessary - manually slightly corrected. Through this there is provided a three dimensional model in digital form of the cap provided in Fig. 2 with the reference sign 2, which with regard to its structure corresponds exactly to the moulded part to be produced.

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A significant step of the method in accordance with the first inventive insight is illustrated in Fig. 3, in which the cap 2 is provided within the scope of the three dimensional modelling or CAD reconstruction with an offset
25 2a, that is an additionally applied layer on the cavity and/or occlusal side. This offset 2a may depend on the one hand upon the structure on the moulded part to be produced and on the other hand upon the type of material, and typically lies in the range from ca. 0.5 mm. It may
30 partially or completely cover the model 2.

In accordance with the illustration in Fig. 4 this offset 2a can then be additionally modelled, i.e. provided with supplementary layers 2b and 2c, so that overall there is provided an offset form, generally given the reference sign 3, which approximately corresponds to the form of the moulded part to be produced, but - partially or on all sides - is surrounded with an additional layer. The supplementary modelling of the offset 2a can be employed in particular to form a relatively simple surface structure for the offset form 3, through which the subsequent production of the coquille for carrying out the casting method is facilitated.

In a next step a coquille is thus then to be produced, as it is illustrated in Fig. 5 and provided with the reference sign 10, wherein the coquille 10 is to have an hollow space 11 which corresponds to the structure of the moulded part provided with the - if appropriate, modified - offset.

The production of the coquille is effected, correspondingly to the illustrated exemplary embodiment, fully automatically, wherein initially a NC program for the production of the coquille is generated with the aid of a CAM module and taking into account the model geometry. The CAM module thereby generates automatically the mould division and the suitable milling program in order to form the hollow space 11.

The production of the coquille is illustrated in Figs. 6a and 6b, wherein for this purpose initially a first coquille blank 12, consisting of a suitable material 13, is placed in a mounting bridge of a material removing machine, for

example a milling, turning, boring or grinding machine, and worked for material removal with an appropriate tool 5, in order to form the lower outer surface 14 of the hollow space. A second coquille blank 15, illustrated in Fig. 6b, is in turn so worked with the aid of the tool 5 that the upper bounding surface 7 of the hollow space is provided. Depending on the geometry of the coquille, one or two coquille blanks are thus worked, preferably five-axis milled, so that finally in the assembled condition a hollow space is formed the structure of which corresponds to the offset form 3 illustrated in Fig. 4. During the carrying out of the milling procedure, at the same time there may be automatically generated an NC program for the later working of the casting, which is necessary in order to attain the desired crown cap geometry with a suitable cavity and the desired occlusal side.

It is important that in the working of the coquille blanks 12 or 15 appropriate inlet channels 21 - illustrated in Fig. 7 - can already be provided, which will later be used to fill the hollow space 11 with the liquid alloy. As soon as the coquille or the coquille halves have then been appropriately worked they can be taken out with the mounting bridge and - insofar as two coquille blanks are involved - assembled together and put in place in the casting apparatus.

The coquille formed in this way is then filled with the noble metal alloy or the Co-Cr-Mo alloy, whereby as a result of the special, millable coquille material, a pre-heating before the casting corresponding to the manner of procedure

known to date is no longer necessary. As soon as the casting provided through this has sufficiently hardened, the coquille 10 - consisting of the two halves 12 and 15, can be again placed in the mounting bridge 19 of the milling machine (Fig. 7), whereby due to the possibilities for precise repositioning, a precision as great as possible is made possible in the later working.

The final working of the casting 20 is now effected in turn with the aid of a material removing tool 6, wherein corresponding to the illustration in Fig. 8 initially the casting 20 is worked from the upper side, until finally a surface 25 arises which in its dimensions and in its structure corresponds to the desired crown cap. In the working cycles "trimming" and "fine trimming" the offset is removed, with the slightest material loss, so that a precisely sized cavity is generated. It is significant that here the outer side of the casting 20 is supported by the remaining coquille material 13 or 16 so that also very fine castings can be worked, without there being the danger that these are thereby damaged, in particular break apart.

Before a final working of the occlusal side the cavity side is again embedded with a bedding material 22, for example an appropriate milling wax or plastic, and thus supported, so that the mould part is safely mounted and supported also during the final working process illustrated in Fig. 10. In this process, the occlusal side is then milled, until finally also this side has a surface structure 26 which corresponds to the desired crown structure.

After conclusion of the milling process, the worked casting 20 is removed from the machine and released from the bedding wax or plastic, which e.g. may be effected by means of heating with the aid of a hot air blower. In rare cases 5 final slight correction is necessary with the aid of a dental motor handpiece in order to work again the inner side of the cavity.

The crown cap provided in this way is then briefly blasted 10 inside and outside at the veneer surface in a blasting apparatus, whereafter, after appropriate removal of contaminant particles and the like, with cleaning of the tooth stump, the cap is put in place and the final operations can be carried out.

15 The described work procedure makes clear that in contrast to the classical dental casting method the primary activities of the dental technician are redirected to the CAD/CAM work station and to the CNC controlled, preferably 5-axis, 20 milling machine. The great part of the complex manual activities are thus avoided, as is also shown by the comparison in the table of Fig. 11. Here it is clear that many working steps are transferred to the PC or the machine and in particular may also run automatically. The remaining 25 manual tasks, in contrast, are mainly such that they can be carried out very quickly.

A further advantage is provided in that the millable 30 coquille need not, as was to date usual, be pre-warmed in a controlled thermal process over an extended time, and transferred in the hot condition into the casting apparatus.

Since the coquille material is well millable or grindable without great tool wear, after the coquille casting it can at the same time serve as mounting of the cast piece in the mounting bridge. Here there is provided as an advantage not
5 only that a support of the casting during the finishing working is effected. At the same time it is ensured that an extremely precise repositioning is made possible. Due to these advantages one can work with a very thin offset and expensive noble metal can be saved. In the employment of Co-
10 Cr-Mo alloys, in contrast, due to the slight volume removal, tool wear is reduced, which in turn makes possible a production which covers its costs.